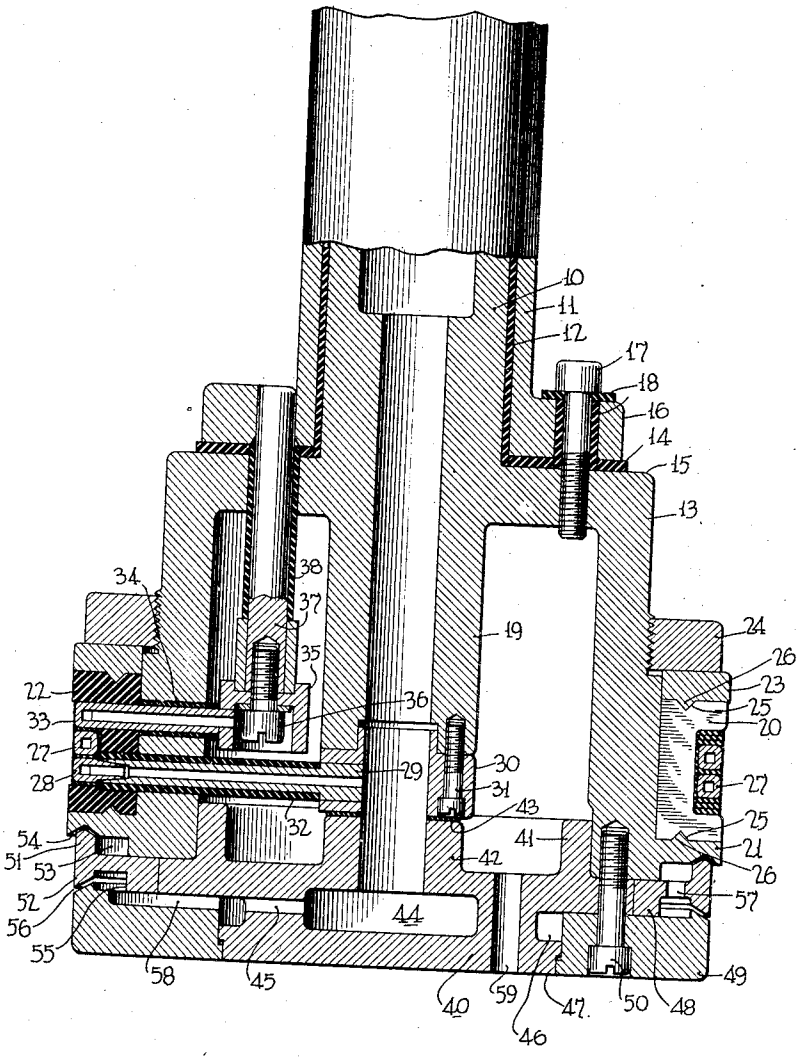
June 30, 1942. H. E. SOMES 2,288,041

INDUCTION HEAT TREATING APPARATUS

Original Filed Sept. 17, 1937



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Patented June 30, 1942

2,288,041

UNITED STATES PATENT OFFICE

2,288,041

INDUCTION HEAT-TREATING APPARATUS

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Original application September 17, 1937, Serial No. 164,320. Divided and this application September 23, 1941, Serial No. 411,963

15 Claims. (Cl. 219—13)

This application is a division of my copending application, Serial No. 164,320, filed September 17, 1937.

The present invention relates in general to the heat treatment of objects by electromagnetic induction and, in particular, to improvements in induction heating heads for use in connection therewith.

In a copending application Serial No. 50,829, filed November 21, 1935, now Patent No. 2,256,873, dated September 23, 1941, there is shown and described an induction heating head which is particularly adaptable for heating hollow workpieces. Such head embodies a coil wound upon a laminated iron core which, in turn, is supported by a mandrel. The present invention has to do with induction heating heads of this general character. Heretofore; it has been impossible in low turn stationary inducing coils to attain the desired extreme uniformity in the application of the heating energy, particularly as to the rate of energy input and the total amount of energy applied throughout an annular zone being heated. This is due to considerable extent to the necessity for current leads and the insulation therefore, and the presence and previous location of such leads, preventing unit coil turns of 360 degrees.

One of the objects of the present invention is to provide an induction heating head with an improved arrangement and organization of the elements comprising the same, particularly those elements which conduct the electric heating currents to the heating coil, wherein such elements are so associated with the heating coil as to enable the attainment of the desired uniformity of heating energy.

Another object is the arrangement of the current leads for the heating coil and the insulation therefore in such manner as to permit each turn of the heating coil to have a complete unit turn of 360 degrees whereby to minimize interference with uniform distribution of the magnetic flux.

A further object is to provide an induction heating head with an improved organization of parts for circulating cooling medium through the heating coil thereof to provide for efficient cooling of the coil.

A still further object is to provide an improved arrangement wherein the leads for the heating coil are arranged within the body of the induction heating head.

With the above and other objects in view, which will be apparent to those skilled in the art to which the invention appertains, the present invention consists in certain features of construction and combination of parts to be hereinafter described with their accompanying drawing and then claimed.

Referring to the accompanying drawing, the single view illustrates a suitable embodiment of the invention.

In the drawing in which like numerals refer to like parts, the heat treating head on which the coil 27 is mounted embodies a hollow mandrel 10 and a concentric, surrounding conductor sleeve 11 which is insulated from the mandrel 10 by an intervening sleeve 12 of an electrically non-conductive material.

The mandrel 10 and conductor sleeve 11 are connected with the terminals of a transformer secondary (not shown) in a manner and are supported in a manner shown in my copending application, Serial No. 164,320, aforesaid.

The lower end of the mandrel 10 is formed with an enlarged tubular extension 13, there being a body 14 of insulation material interposed between the shoulder 15 formed by the extension and a mounting flange 16 on the lower end of sleeve 11. The flange 16 is secured to the mandrel 10 by means of bolts 17 (only one being shown) threaded through shoulder 15, a body 18 of insulation being intervened between bolts 17 and metal of flange 16 to prevent the passage of current between the shoulder 15 and flange 16.

The mandrel 10 is also provided with an inner tubular extension 19 which is of lesser axial extent than the outer extension 13.

The outer tubular extension 13 carries an iron core in the form of an annular series of taper-ground radial laminations 20 seating at the bottom on a circumferential flange 21 at the lower end of the tubular extension 13, an insulation block 22 of rubber or other suitable non-conductor of electricity and of the same cross-sectional configuration as the laminations 20 being interposed at one point in the annular series of laminations, as shown at the left in Figure 2, for a purpose to be later described. The upper ends of the insulation block 22 and the series of laminations are engaged by a clamping ring 23, a nut 24, threaded on the extension 13, being provided to clamp the block 22 and laminations between the flange 21 and the clamping ring 23. In order to insure annular alignment of the laminations 20 it is desirable to provide the same and the block 22 with annular V-shaped recesses 25 to receive correspondingly shaped annular projections 26 on the flange 21 and clamping ring 23

so that as the laminations are being clamped in position they will be caused to move into annular alignment.

The induction heating element is in the form of a tubular conductor 27 coiled about the block 22 and the annular series of laminations 20. The conductor is disposed within a peripheral recess in the laminations 20 and block 22 and is insulated, as shown, from the laminations. One terminal 28 of the conductor is electrically connected with the inner tubular extension 19 through a radially extending conduit 29 which is fitted within an opening in the sidewall of an annular ring 30 clamped to the end of the inner tubular extension 19 by screws 31 (only one being shown). The portion of the conduit 29 which extends through the outer tubular extension 13 is electrically insulated therefrom by a body 32 of suitable insulating material. It is to be noted that the conduit 29 is in open communication with the interior of the annular ring 30 which, in turn, is in open communication with the bore of the tubular mandrel 10.

The other terminal 33, of the conductor 27 extends radially through the outer tubular extension 13 and is insulated therefrom by a body 34 of suitable insulation material, and the end of this terminal is electrically connected with and in open communication with the interior of an inverted cup shaped member 35 which is secured in electrical contact by a cap screw 36 to a vertical conductor rod 37. The rod 37 extends through the radial wall of the outer extension and through the flange 16 of the sleeve 11, to which such rod 37 is secured in any suitable manner, such as for example, by brazing. It is to be noted that the conductor rod 37 is insulated from the wall of the outer extension 13 by a body 38 of suitable insulating material. It is to be noted also that the terminals 28 and 33 are imbedded in the insulation block 22, thus insuring complete insulation for the same.

The electrical circuit of the coil 27 may thus be traced from one terminal of the transformer (not shown), shown and described in my copending application Serial No. 164,320 aforesaid, through the mandrel 10 and inner extension 19, conduit 29, and coil terminal, through the heating coil 27 and thence from upper terminal 33, member 35 and conductor rod 37 to the sleeve 11 and back to the other terminal of the transformer.

It is thus seen that the leads or terminals for the induction heating coil 27 are arranged within the head proper and also such terminals are electrically connected to concentric tubular conductors insulated from each other with the result that none of such leads or connections are exposed to interfere with the operation of the heating head.

It is to be noted that the inwardly extending portions of the terminals 28 and 33 are arranged one above the other and that by axially offsetting such terminals relative to the normal planes of the coil turns each unit turn of the coil is enabled to have a circumferential extent of 360 degrees. By so arranging the heating coil, attainment of the desired uniformity of application of heating energy throughout the annular zone being heated is enabled, also interference with the uniform distribution of magnetic flux is minimized.

The axial extent of the heating coil described is extremely short compared with the diameter so that the magnetic circuit if restricted in axial extent to several times less than the diameter, and the depth of the high density magnetic flux and consequently the depth of the treated zone may be kept small, and this regardless of the size of the workpiece.

The heating head of the present invention, as set forth in my copending application Serial No. 164,320, is of the type suitable for use in progressively heating cylindrical workpieces and in connection with which a quenching nozzle is employed. The direction of movement, of course, of the heating head is such that as the head is moved through the cylindrical workpiece the coil 27 first heats the bore of the workpiece throughout an annular zone which is followed by the quenching operation as the head progresses. As viewed in the drawing such progressive movement will be in an upward direction.

The quench nozzle is associated with the bottom of the head and to which quenching fluid, such as water under pressure, is supplied through the extension 19 of the hollow mandrel 10. The quench nozzle embodies a casting 40 engaged with the end of the outer extension 13 and having an annular flange 41 tightly fitting within the extension and a central annular hub 42 engaged with ring 30 through a sealing washer 43. The casting 40 is cored out below the opening in the hub 42 to provide a chamber 44 which communicates through radial passages 45 (only one being shown) with a circumferential recess 46 formed in a cylindrical portion 47 of reduced diameter at the lower side of the casting.

The quenching nozzle proper is provided by an annular ring 48 surrounding the casting 40 and abutting the end of the outer tubular extension 13, and a clamping ring 49 which through the medium of cap screws 50 (only one being shown) clamps the casting 40 and ring 48 against the end of the outer extension 13, the clamping ring having sealed engagement with the portion 47 of reduced diameter to close the recess 46.

The ring 48 is provided with opposed circumferential flanges 51 and 52, the flange 51 forming an annular chamber 53 and being axially spaced from shoulder or flange 21 to provide a circumferential quench passageway 54, and the flange 52 forming an annular chamber 55 and being axially spaced from the peripheral edge of ring 49 to provide a second circumferential quench passageway 56 axially spaced from passageway 54.

The annular chambers 53 and 55 are in communication through openings 57 (only one being shown) and the chamber 55 communicates with the closed recess 46 through a passage 58. It is to be noted that the casting 40 is provided with an axial passage 59 opening therethrough into the closed chamber defined by the outer and inner extensions and the casting 40. Additional passages, such as passage 59, may be provided through casting 40.

As set forth in my copending application aforesaid, fluid for cooling the heating coil and for quenching is supplied to the hollow mandrel 10. The cooling fluid flows through the mandrel 10 to the lower end where a portion thereof flows through conductor conduit 29, thence upwardly through the coil and through the hollow terminal 33 where it discharges from the inverted cup-shaped member 35 into the chamber defined by the mandrel extensions 13 and 19 and the end casting 40. This fluid then is free to discharge below the head through the passage 59.

The remainder of the cooling fluid flowing

through mandrel 10 flows from the chamber 44 through the radial passageways 45 and 58 to the intercommunicating chambers 53 and 55 for radial quenching distribution through the circumferential nozzle passageways 54 and 56.

In the operation of the heating head, it is to be understood, of course, that the quenching and cooling fluid will be supplied at such volume and pressure that the back pressure built up in the chamber 44 due to the restricted flow through the continuously open annular nozzle passages 54 and 56 will be sufficient to force the cooling fluid through the coil 27 from the trailing terminal thereof to the leading terminal in the direction of progressive movement of the heating head through the workpiece.

It is to be noted that by arranging the open nozzle passage 54 at the underside of the abutment flange 26 for the core 20 an annular jet issues substantially directly from the lower edge of the flange 26 with the result that the zone of the initial contact of the quenching fluid with the workpiece is brought into extremely close proximity to the trailing end of the heated zone which is the hottest portion of the heated zone due to its relatively longer exposure to the heating influence of the heat treating head. It is to be noted further that an advantage of the arrangement whereby the cooling fluid is directed through the hollow conductor of the coil 27 from the bottom to the top, that is, in the direction of travel of the coil relative to the workpiece, is that that part of the coil which is presented to the hottest portion of the progressing head zone is the first to receive the cooling fluid. Also, because the coil is intended to travel upwardly through the workpiece with the result that it is the lowest terminal of the coil which is presented to the hottest part of the heated zone, this is the one selected for connection with the mandrel 10 whereby that portion of the coil is maintained at substantially the same potential as the workpiece.

There has thus been described a heat treating head of improved, yet simple and compact construction. The particular manner of arranging the current conducting leads for the heating coil and the manner of cooling the coil materially add to the efficiency of operation.

It is to be understood that the invention may be embodied in various modifications and arrangements which may be made without departing from the spirit of the invention as will be apparent to those skilled in the art. Accordingly reference will be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. An induction heating head comprising inner and outer concentric members of electrically conductive material, means electrically insulating said members from each other, an annular induction heating element surrounding one of said members, and a pair of terminal conductors for said heating element arranged within the confines of the annulus thereof, one of said conductors being electrically connected to one of said members and the other of said conductors being electrically insulated from said last mentioned one member and being electrically connected to the other of said members.

2. An induction heating head comprising inner and outer concentric members of electrically conductive material, means electrically insulating said conductors from each other, one of said members extending axially beyond the other, an annular induction heating element surrounding said extending member and being supported thereby, and a pair of terminal conductors arranged within the confines of the annulus of said member and connected with said element, one of said conductors being electrically connected to said extending member and the other of said conductors extending through and being insulated from said extending member and having an electrical connection with said other member.

3. An induction heating head comprising inner and outer concentric members of electrically conductive material, means electrically insulating said conductors from each other, said inner member having a portion extending axially beyond said outer member, an annular inductive heating element surrounding said extending portion and being supported by said portion, and a pair of terminal conductors for said heating element, one of said conductors being electrically connected with said inner member inwardly of the annulus of said heating element, and the other of said conductors extending through the wall of said inner member and electrically connected with said outer member, said last mentioned conductor being electrically insulated from said wall of said inner member.

4. In an induction heating head, a multi-turn inducing coil, a support therefor comprising tubular concentric conductors, means electrically connecting said coil at one end to the inner of said conductors, and means electrically connecting the other end of said coil to the outer of said conductors through an insulated connection passing through the wall of said inner conductor.

5. In an induction heating head, a pair of concentric conductors, the inner extending axially beyond the outer and having a tubular extension, an induction heating coil mouted on said extension, means electrically connecting one end of said coil with said inner conductor, and means extending through and insulated from the wall of said extension and electrically connecting the other end of said coil with said outer conductor.

6. In an induction heating head a pair of concentric conductors, the inner extending beyond the outer and having an extension of enlarged diameter providing a shoulder and a tubular portion, means insulating said conductors from each other, an induction heating coil supported by said tubular portion and having one end electrically connected therewith, means extending through the wall of said tubular portion and through the wall of said shoulder for electrically connecting the other end of said coil with said outer conductor, and means insulating said last named means from said walls.

7. In an induction heating head, a conductor having a tubular portion, an annular magnetic core carried by said tubular portion, said core having a segmental block of insulation in a short section thereof, an induction heating coil supported by said core and terminal connections for the ends of said coil, said terminal connections extending through said block, one of said connections being electrically connected to said conductor and the other of said connections extending through the wall of said tubular portion and being insulated therefrom.

8. In an induction heating head, a pair of concentric conductors insulated from each other, an annular magnetic core carried by one of said conductors, said core having a segmental block of insulation in a short section thereof, an induction heating coil supported by said core, and

terminal connections for said coil, one of said connections extending through said block and being electrically connected with the supporting conductor, and the other of said connections extending through said block and the wall of the supporting conductor and being electrically connected with the other conductor, said last mentioned connector being insulated from said wall.

9. In an induction heating head, a mandrel having an inner tubular extension and a concentric outer tubular extension providing a chamber therebetween, an induction heating coil supported on said outer extension, said coil having a coolant-conducting passageway therethrough and tubular connectors for the ends of said coil extending through said outer extension, one of said connectors being in open communication with said chamber and the other of said connectors extending through the inner extension into open communication therewith.

10. In an induction heating head, a mandrel having an inner tubular extension and a concentric outer tubular extension providing a chamber therebetween, an induction heating coil supported on said outer extension, said coil having a coolant-conducting passageway therethrough and tubular connectors of electrically conductive material for the ends of said coil extending through said outer extension, one of said connectors being in open communication with said chamber and the other of said connectors extending through the inner extension into open communication therewith, one of said connectors being in electrical engagement with said mandrel and the other of said connectors being insulated from said mandrel, and a conductor electrically connected with said last mentioned connector.

11. In an induction heating head, wall means forming a coolant-receiving chamber, wall means forming a coolant passageway separate from said chamber, an induction heating coil surrounding and supported by said first mentioned wall means, said coil having a coolant-conducting passageway therethrough, and coolant-conducting connections of electrically conductive material for said coil, each extending through said first mentioned wall means, one of said connections being in open communication with said chamber and the other of said connections extending through said second mentioned wall means into open communication with said passageway, one of said connections being electrically insulated from said first mentioned wall means.

12. In an induction heating head, a coolant-conducting heating coil, means within the annulus of said coil for supporting the same and forming a chamber, a coolant-conducting connection for one end of said coil extending through said means for discharging coolant from said coil into said chamber and a second coolant conducting connection for the other end of said coil extending through said means, said head having an internal axial passageway therein connected with said second connection for conducting coolant thereto.

13. In an induction heating head, a coolant-conducting heating coil, means within the annulus of said coil for supporting the same and forming a chamber, a coolant-conducting connection for one end of said coil extending through said means for discharging coolant from said coil into said chamber and a second coolant conducting connection for the other end of said coil extending through said means, said head having an internal axial passageway therein connected with said second connection for conducting coolant thereto, said head having outlet means for said chamber opening from said chamber axially with respect to said coil.

14. Apparatus for progressively heat-treating a surface portion of an elongated workpiece by electro-magnetic induction comprising a supporting member movable longitudinally of the surface portion to be heat treated, a hollow inducing element supported by and being movable by the supporting member relative to and closely adjacent the surface portion of the workpiece to be heat treated, the trailing end of said coil being susceptible to being heated by the heat of the surface portion undergoing heating to a temperature higher than that of the leading end thereof, and means for directing a cooling fluid through the inducing element from the trailing to the leading end thereof, whereby the cooling fluid first cools the portion of said coil which is at greater temperature to maintain said coil portion at substantially the same potential as the workpiece surface undergoing heating.

15. Apparatus for progressively heat-treating the internal surface portion of an elongated hollow workpiece by electro-magnetic induction comprising an annular supporting member, a tubular inducing coil supported by and being movable by said supporting member axially of the surface portion to be heat treated, and means for directing a cooling fluid through the inducing coil from the trailing to the leading end thereof, said supporting member having a chamber therein, the leading end of said coil being in open communication with said chamber for discharging cooling fluid into said chamber, said chamber having an exhaust passage for discharging the cooling fluid received thereby.

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